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Agricultural Activities and Their Spatial Distribution in Naour District Using GIS

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Abstract

Objectives: This study aimed to analyze the spatial distribution of agricultural activities in the Naour District of Jordan using Geographic Information Systems (GIS) and remote sensing techniques. It sought to develop a comprehensive agricultural geodatabase to support decision-making, inform planning processes, and promote sustainable agricultural practices.

Methods: ArcGIS 10.5 and Landsat 8-OLI/TIRS satellite imagery generated climate, elevation, slope, NDVI, and land use maps. A supervised classification was performed using the Maximum Likelihood Classifier (MLC). Data from the Naour Agriculture Directorate and field surveys were integrated into a spatial database.

Results: NDVI analysis for three seasonal periods (January, June, and October 2022) revealed vegetation cover variation. Supervised classification identified forests (6.25 km²), bare soil (64.52 km²), crops (22.67 km²), irrigated lands near Husban stream (13.08 km²), urban areas (52.16 km²), and fruit plantations (42.14 km²), with an overall classification accuracy of 82.4% and a Kappa coefficient of 0.77.

Conclusions: The study demonstrates the value of GIS and remote sensing in mapping and managing agricultural activities. The generated maps and geo-database provide a strategic tool for resource allocation, agricultural development, and environmental planning in Naour District.

Keywords: Naour district, GIS, remote sensing, NDVI, supervised classification, dem.

ٱلْأَنْشِطَةُ ٱلزِّرَاعِيَّةُ وَتَوَزُّعُهَا ٱلْمَكَانِيُّ فِي لِوَاءِ نَاعُورَ بِٱسْتِخْدَامِ نُظُمِ ٱلْمَعْلُومَاتِ ٱلْجُغْرَافِيَّةِ(GIS)

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الملخص

الأهداف: هدفت هذه الدراسة إلى تحليل التوزيع المكاني للأنشطة الزراعية في لواء ناعور في الأردن باستخدام تقنيات نظم المعلومات الجغرافية (GIS)والاستشعار عن بعد، وذلك بهدف إنشاء قاعدة بيانات جغرافية زراعية شاملة تدعم عملية اتخاذ القرار والتخطيط وتعزيز ممارسات الزراعة المستدامة.

المنهجية: تم استخدام برنامج ArcGIS 10.5 وصور الأقمار الصناعية Landsat 8-OLI/TIRS لإنتاج خرائط المناخ، الارتفاع، الانحدار، مؤشر الاختلاف الطبيعي للغطاء النباتي(NDVI) ، واستخدامات الأراضي. كما طبق التصنيف المراقب باستخدام طريقة المصنف الاحتمالي الأقصى .(MLC) وجرى دمج بيانات مديرية زراعة ناعور مع نتائج الزيارات الميدانية ضمن قاعدة بيانات مكانية.

النتائج: كشفت تحليلات NDVI لثلاث فترات زمنية (كانون الثاني، حزيران، وتشرين الأول 2022) عن تباين في كثافة الغطاء النباتي. وقد حدد التصنيف المراقب الغابات (6.25 كم²)، الأراضي الجرداء (64.52 كم²)، المحاصيل الزراعية (22.67 كم²)، الأراضي المزروعة قرب سيل حسبان (13.08 كم²)، المناطق العمرانية (52.16 كم²)، مزارع الأشجار المثمرة (42.14 كم²)، بدقة تصنيف كلية بلغت 82.4% ومعامل كابا 0.77.

الاستنتاجات: تؤكد الدراسة أهمية نظم المعلومات الجغرافية وتقنيات الاستشعار عن بعد في رسم خرائط الأنشطة الزراعية وإدارتها. وتوفر الخرائط الناتجة وقاعدة البيانات أداة استراتيجية لتوزيع الموارد وتخطيط التنمية الزراعية والإدارة البيئية في لواء ناعور.

الكلمات المفتاحية: لواء ناعور، نظم المعلومات الجغرافية، الاستشعار عن بعد، مؤشر NDVI ، التصنيف المراقب، نموذج الارتفاع الرقمي.

Introduction

Naour District in Jordan comprises many small agricultural holdings, necessitating individualized or grouped attention to facilitate service provision by the Ministry of Agriculture. These services include registering agricultural holdings and supporting labor allocation. To streamline these processes, there is a pressing need to store, organize, manage, and analyze agricultural data efficiently. This study responds to that need by proposing the creation of an agro-geographic database visualized through Geographic Information Systems (GIS) and remote sensing techniques, offering reliable and up-to-date spatial information (Oymatov & Safayev, 2021).

Remote sensing (RS) and GIS are essential technologies for surveying and monitoring land cover, which refers to the physical presence of vegetation or observable surface features, and land use, pertains to human activities on specific parcels of land (Di Gregorio, 2016). These tools are crucial for producing detailed spatial maps that help describe the distribution and extent of land use types, supporting better decision-making with minimal cost and improved resource management. For instance, Kazem (2019) applied RS and GIS to assess land use in the Al-Jazira irrigation project in Nineveh, Iraq, demonstrating their effectiveness through ERDAS Imagine and ArcGIS-based analysis.

In Naour district, diverse agricultural practices are present, including the cultivation of fruit trees, field crops, and vegetables, alongside livestock farming such as sheep, cattle, horses, and poultry. To reflect ongoing environmental and land use changes, a dynamic and regularly updated database is required. Such updates rely heavily on GIS and RS methodologies, which facilitate the creation of representative maps that link real-world phenomena to their geographic coordinates. The Naour region in Jordan is an important agricultural area that contributes to the national economy through the production of numerous agricultural crops. Agriculture in Naour plays a vital role in providing food, creating jobs, and enhancing food security. The area used for agriculture is 47,564 dunums, where fruit trees constitute an area of 24,264 dunums. The area of field crops is 7,600 dunums, 7,700 of which is used for cultivation of vegetables. Forest lands constitute an area of 36,000 dunums, where the area used for forest trees is 8,000 dunums, including forests with an area of 7,293 dunums. The district is also distinguished by its livestock wealth, where the number of sheep and goats is 60,580 thousand heads, and it has many poultry, cow and horse farms, as well as beehives (2021, Naour Agriculture district, Annual report).

Compared to the traditional methods of data collection and management, these technologies offer superior efficiency. Abo Rokbeh (2019) emphasized the importance of RS and GIS in generating vegetation and natural feature maps and guiding resource planning. Similarly, Jawarneh and Biradar (2017) highlighted the utility of these technologies for future-oriented land management.

Additional datasets were derived from the National Soil Map and Land Use Project (1993), including maps of climate, average rainfall, groundwater basins, soil moisture, and salinity. Slope degree and contour lines were generated using Digital Elevation Models (DEM). To assess vegetation cover, Normalized Difference Vegetation Index (NDVI) maps and supervised land classification using the Maximum Likelihood Classifier (MLC) were produced from satellite imagery. Taufik et al. (2016) demonstrated the creation of NDVI maps using Landsat 8, while Al-Mashagbah (2016) applied NDVI to detect vegetation changes in the Ajloun region.

Study Problem

The agricultural sector is widely recognized as a vital contributor to national economies, especially in developing countries. Its advancement is essential not only for food security but also for rural development, employment generation, and sustainable natural resource use. Therefore, it is critical to modernize agricultural practices and improve the quality of services provided by this sector through the adoption of advanced technologies and tools such as Geographic Information Systems (GIS) and Remote Sensing (RS).

The focus on Naour District stems from direct observations made during professional service at the Naour Agriculture Directorate. A key issue identified is the absence of a centralized and accessible system for collecting and documenting agricultural data. This gap hinders consistent monitoring and evaluation, causing delays in operations and reducing the effectiveness of interventions aimed at solving emerging problems. Moreover, the Directorate lacks a computerized system or digital platform to document the spatial and attribute data related to agricultural holdings, resulting in data fragmentation and loss over time. These limitations prevent the optimal utilization of opportunities for agricultural development and strategic planning in Jordan.

Study Objectives

The main objective of this study is to establish a comprehensive agro-geographic database that integrates all agricultural sectors within the Naour Directorate using GIS and remote sensing technologies. Specific objectives include:

1. To create digital maps of agricultural activities to support data-driven decision-making and enable local authorities to generate periodic, reliable statistical reports.
2. To develop a robust and reliable information system that organizes and manages agricultural data across all sub-sectors using GIS tools.
3. To generate land cover and land use classification maps using the Normalized Difference Vegetation Index (NDVI) and supervised classification methods.
4. To validate and supplement spatial information using records from the Naour Agriculture Directorate.

Study Importance

1. To provide timely, accurate, and updated spatial data that Supports policy-making, service enhancement, and rapid response in agricultural planning.
2. To improve the quality and detail of agricultural and land cover data on the national level, particularly in:
    - **Plant production**: Including cultivated areas, varieties, ownership, nursery grounds, and responsible agricultural engineers.
    - **Livestock**: Geographic distribution of livestock facilities.
    - **Projects**: Location, beneficiaries, types of implemented projects, and areas of implementation.
    - **Forestry**: Distribution and size of forested and afforested areas.
3. To apply modern technological methods for efficient data collection, spatial analysis, and information dissemination.

Study Area

Naour District is located in central Jordan, between latitudes 31°54′50″ and 31°45′50″ N, and longitudes 35°54′20″ and 35°43′20″ E. The district comprises 123 basins and includes 11 villages: Naour, Umm Al-Bsateen, Husban, Al-Mashager, Qurmyet Husban, Al-Aal and Al-Rawdah, Zabood and Sail Husban, Masoh, Al-Samek, and Al-Bnyyat Umm Al-Kondum. The total area of Naour District is approximately 216 km², with an estimated population of 120,000 residents (see Figure 1):

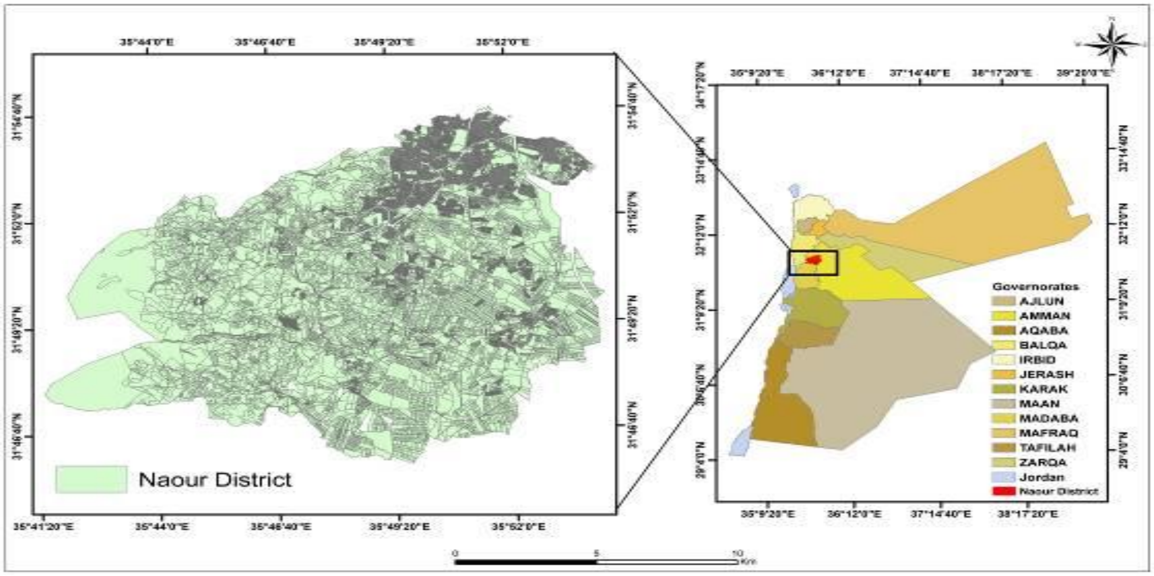

Figure 1. Location map of Naour District within Jordan and internal sub-basin divisions.
Source: Prepared by the researcher using ArcGIS 10.5.

Climate

Jordan is situated in the West Asia region and is predominantly characterized by dry to semi-dry climatic conditions, with regional variations depending on elevation and proximity to water bodies. According to the National Climate Change Adaptation Plan of Jordan (2021), these arid and semi-arid conditions influence agricultural productivity, water availability, and land use planning. Naour District, specifically, falls within the semi-dry climatic zone, which is marked by moderate rainfall and relatively high evaporation rates. These conditions present both challenges and opportunities for sustainable agricultural development.

The climate map shown in **Figure 2** illustrates the spatial distribution of climatic characteristics across the study area, derived from the National Soil Map and Land Use Project.

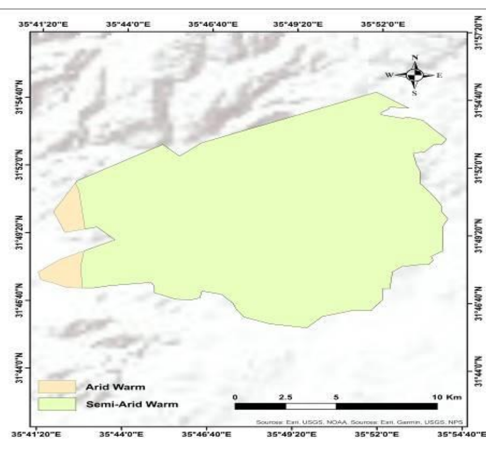

Figure 2. Climate zones of Naour District.
Source: Researcher’s work based on National Soil Map and Land Use Project (1993).

Rainfall Average

Rainfall in Jordan is generally concentrated between November and April. The northwest region of the country receives the highest annual precipitation, typically ranging between 300 and 350 mm. In contrast, much of the eastern and southern regions receive less than 100 mm per year, classifying them as arid zones. Consequently, the majority of the country's territory is considered desert.

Naour District lies in a relatively favorable climatic zone, with most areas receiving between 300 and 350 mm of annual rainfall. This distribution supports a variety of agricultural activities and justifies the application of GIS-based planning tools. The spatial pattern of rainfall within the study area is illustrated in Figure 3:

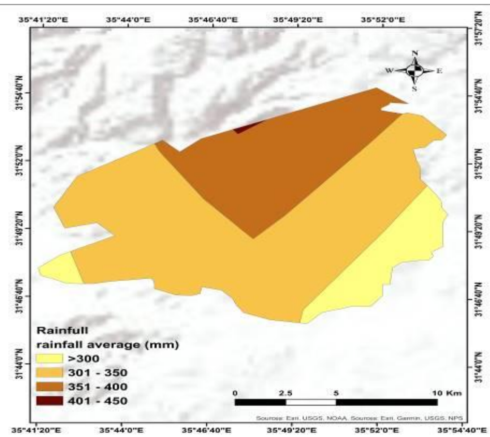

Figure 3. Average annual rainfall distribution in Naour District.

Source: Researcher's work based on National Soil Map and Land Use Project (1993).

Precipitation data, maximum Temperature, minimum Temperature, Relative Humidity, Dew/Frost Point, and wind speed for the period (2018_2021) were downloaded from the open source (https://power.larc.nasa.gov/data-access) for Queen Alia International Airport station, table 1.

Climatic Data

To provide a detailed understanding of the weather conditions influencing agricultural activities in Naour District, monthly climate data for the period 2018–2021 were obtained from the Queen Alia International Airport meteorological station (31°43′21″N, 35°59′36″E, elevation 730 m). These data include monthly averages for temperature, humidity, wind speed, dew point, and precipitation. The source of the data is the open-access NASA POWER database (https://power.larc.nasa.gov/data-access).

Table 1 summarizes the key climatic indicators for the year 2021, which is representative of recent climate patterns relevant to the study.

Table (1) Climatic Monthly Data for Queen Alia International airport station 31°43′21″N 35°59′36″E, elevation 730 m

year	/Month	T2M (C°) Temperature at 2M	RH 2M (%) Relative Humidity at 2M	WS2M (m/s) Wind Speed at 2M	T2MDE(C) Dew/Frost Point at 2M	T2M_MAX(C°) Temperature at 2M Maximum	T2M_MIN(C°) Temperature at 2M	Precipitation (mm/day)
2021	Jan	8.98	65.94	3.77	2.15	20.94	-2.65	1.19
	Feb	10.29	64.12	3.02	2.59	23.55	0.73	1.32
	Mar	12.44	62.88	3.35	4.01	33.42	1.35	0.17
	Apr	18.41	42.31	3.19	2.44	36.74	2.92	0.01
	May	23.97	35.5	3.47	4.65	39.88	11.73	0.02
	Jun	24.36	43.19	3.79	7.93	37.82	12.86	0
	Jul	27.29	45.62	4.02	11.7	41.43	16.91	0
	Aug	27.74	41.81	3.37	10.55	39.87	16.9	0
	Sep	23.93	51.62	3.24	10.9	41.09	13.59	0
	Oct	20.84	50.56	2.52	7.81	34.18	11.95	0.01
	Nov	16.33	46.69	2.81	3.1	30.19	7.17	0.23
	Dec	10.13	65.56	3.52	3.08	23.41	0.82	0.63
	Annual	18.77	51.25	3.34	5.94	41.43	-2.65	105

Abbreviations:

- **T2M**: Temperature at 2 meters
- **RH2M**: Relative Humidity at 2 meters
- **WS2M**: Wind Speed at 2 meters
- **T2MDE**: Dew/Frost Point at 2 meters
- **T2M_MAX / T2M_MIN**: Maximum/Minimum Temperature at 2 meters

Source: NASA POWER Climate Data Portal (https://power.larc.nasa.gov/data-access)

Groundwater Basins

Jordan is divided into twelve main groundwater basins (Figure 4). These aquifers play a critical role in supporting agricultural and domestic water needs. However, the renewable groundwater resources are facing increasing depletion, primarily due to excessive pumping for irrigation and urban expansion. Given the limited water availability in the country, it is essential to adopt efficient irrigation techniques to ensure water conservation, enhance agricultural productivity, and enable the cultivation of larger areas, even under drought conditions (Ministry of Water and Irrigation,2022).

Naour District lies within the Dead Sea Basin, which is one of the major groundwater basins in Jordan (Figure 5). Understanding the hydrological context of this basin is essential for evaluating the sustainability of agricultural activities and developing water management strategies.

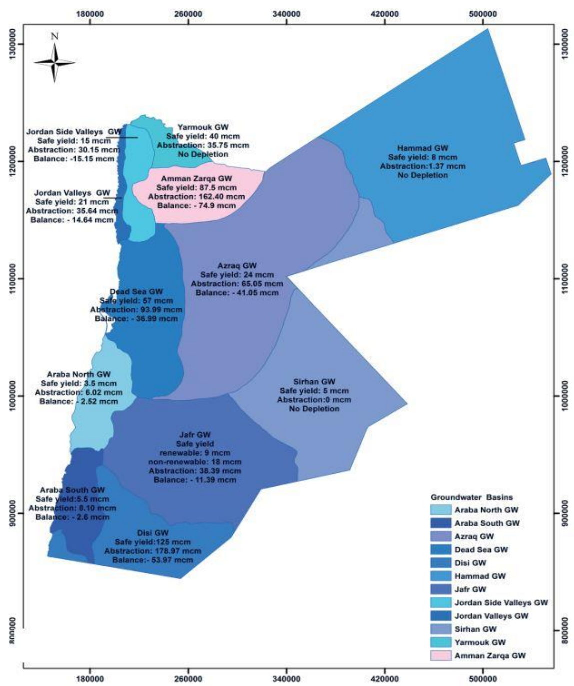

Figure 4. The twelve main groundwater basins of Jordan.

Source: Ministry of Water and Irrigation, Jordan water sector facts and figures (2022).

Naour is located within the Dead Sea Basin, figure (5):

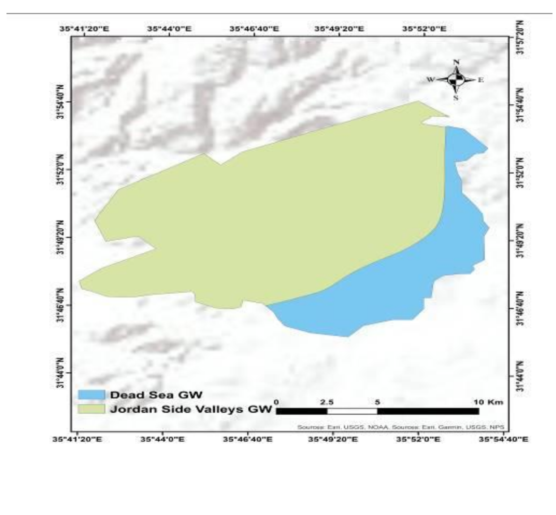

Figure 5. Location of Naour District within the Dead Sea groundwater basin.
Source: Researcher's work based on National Soil Map and Land Use Project (1993).

Soil Moisture Regimes

Soil moisture regimes refer to the availability of water within soil layers that can be utilized by plants. These regimes are classified according to climate and moisture retention characteristics (Plant and Soil Sciences Library, 2022). Based on these classifications, Naour District falls into three major soil moisture regimes:

- **Aridic soils:** These are found in arid climates and require supplemental irrigation for crop growth.
- **Ustic soils:** Common in semi-arid climates, they support rainfed agriculture but may require irrigation during dry spells within the growing season.
- **Xeric soils:** Typical of Mediterranean climates, these soils experience moist and cool winters and dry, warm summers, with annual rainfall ranging between 100 mm and 500 mm.

The spatial distribution of these regimes in Naour is illustrated in **Figure 6**:

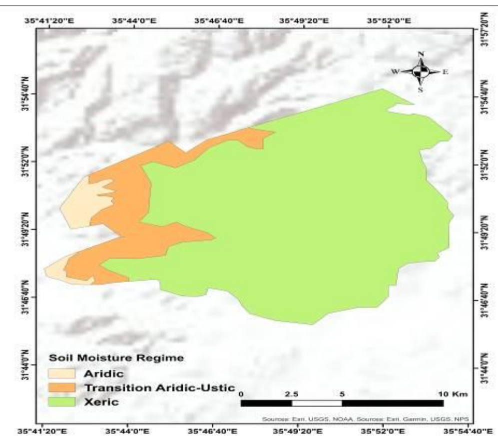

Figure 6. Soil moisture regime zones in Naour District.
Source: Researcher's work based on National Soil Map and Land Use Project (1993).

Digital Elevation Model (DEM)

The topography of Naour District is highly variable, with elevation levels ranging from –26 meters to 977 meters above sea level. This variation influences land use patterns, soil moisture availability, and erosion risk. The Digital Elevation Model (DEM) used in this study provides an accurate representation of terrain features across the district. As shown in Figure 7, the highest elevations are concentrated in the northern and northeastern regions, reaching up to 30*30 m.

Elevation data were downloaded from the U.S. Geological Survey (USGS) and processed using ArcGIS 10.5 to generate slope, contour, and elevation maps, which are critical inputs for spatial analysis and agricultural planning.

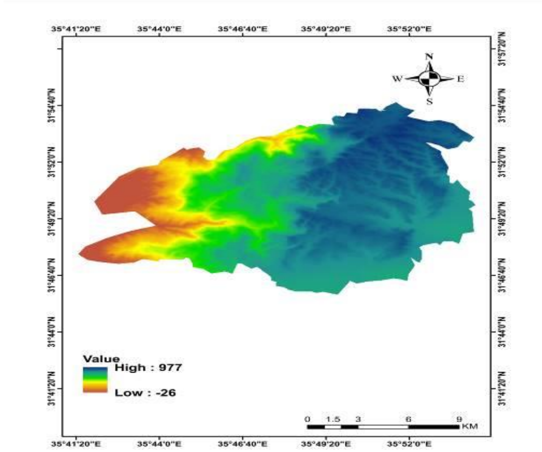

Figure 7. Digital Elevation Model (DEM) of Naour District.
Source: Researcher's work based on DEM from USGS.

Slope

The study area has a slope ranging from 0–14°, increasing in north and southwest areas of Naour (Figure 8). The slope ranges from flat in eastern areas to hilly in western areas, Table 2:

Table (2) Slope degree and percentage classification

Description	Percentage %	Degree (°)
Flat	0 - 3	<2
Undulating	3 - 8	2-5
Moderately sloping	8 - 15	5 - 8
Hilly	15 - 30	8 - 17
Moderately steep	30 - 45	17-24
Steep	45 - 65	24 - 33
Very steep	> 65	> 33

Source: Elewa & Qaddah (2011), based on USDA slope gradient classification.

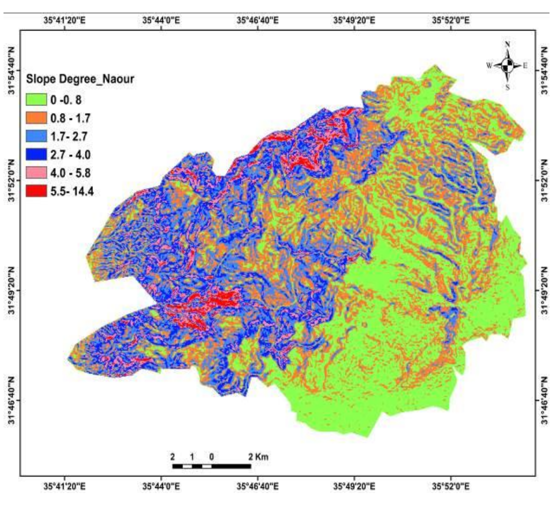

Figure 8. Slope degrees in Naour District.
Source: Researcher's work based on DEM downloaded from USGS, using ArcGIS 10.5

Contour Lines

A contour is a line drawn on a map that joins points of equal elevation. The interval between contours used is 20 meters, and **Figure 9** illustrates Naour contour lines. Western lands of Naour are steep with closely spaced contour lines; on the other hand, the eastern lands have flat plain sand hills where the contour lines are more widely spaced, indicating a gradual elevation change.

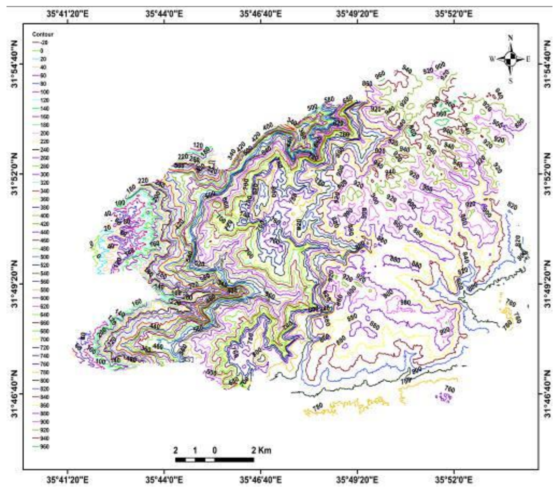

Figure 9. Contour lines in Naour District.
Source: Researcher's work based on DEM downloaded from USGS, using ArcGIS 10.5.

Design and Methodology

Data Used

This study relied on an analytical approach to assess patterns of land cover and vegetation in Naour District for the year 2022. Data were collected from both published and unpublished sources to establish the theoretical framework.

The remote sensing data were obtained from the Landsat 8 archive (Operational Land Imager [OLI] and Thermal Infrared Sensor [TIRS]), specifically for path 174 and row 38, during the seasonal periods of January, June, and October 2022. All satellite images were downloaded from the United States Geological Survey (USGS), using the coordinate system WGS-1984 UTM Zone 36N.

Data preparation, management, and analysis were conducted using ArcGIS 10.5. The software was used for image processing, digitization, indexing, georeferencing, and spatial database creation. Final outputs included land cover classifications, NDVI maps, and topographic visualizations.

Digital Elevation Model (DEM)

The Digital Elevation Model (DEM) was downloaded from publicly available sources on the USGS Landsat platform (http://landsat.usgs.gov/) and was used to generate slope and contour maps for the study area. These maps were crucial for topographical analysis and environmental modeling.

Normalized Difference Vegetation Index (NDVI)

A cloud-free (≤10%) Landsat 8 Collection 2 Level-2 satellite image for each of the three target dates (January, June, and October 2022) was selected, each with a spatial resolution of 30×30 meters. These were downloaded from the USGS Earth Explorer portal (earthexplorer.usgs.gov) for path/row 174/38.

The NDVI was calculated using the Raster Calculator in ArcGIS 10.5's Spatial Analyst toolbox. The formula used is as follows (Asmala, 2015):
NDVI = (NIR – RED)/ (NIR + RED)

NIR reflected light in The near-infrared spectrum, RED reflected light in The red range of the spectrum.

Whereas near-infrared is band 5, and red is band 4 in Landsat8 satellite, table (3).

Table 3. ***Landsat 8 OLI and TIRS Band Designations***

Band	**Wavelength(µm)**	**Resolution(m)**
Band 1 – coastal	0.43-0.45	30
Band 2 – blue	0.45-0.52	30
Band 3 – green	0.52-0.60	30
Band 4– red	0.63-0.69	30
Band 5 - Near Infrared	0.77-0.90	30
Band 6 - Short-wave Infrared	1.55-1.75	30
Band 7 - Short-wave Infrared	2.09-2.35	30
Band 8 - panchromatic	0.50-0.60	15
Band 9 - cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared	10.6-11.19	100
Band 11 - Thermal Infrared	11.5-12.5	100

Source : https://www.usgs.gov/faqs/what-are-band-designations-landsat-satellites.

NDVI Reclassification and Analysis

The Normalized Difference Vegetation Index (NDVI) always ranges between –1 and +1. Values close to zero represent areas with very low vegetation density, such as rocks or barren soil. Negative values typically correspond to non-vegetated surfaces like clouds, water bodies, and snow. Moderate values between 0.2 and 0.3 indicate areas with intermediate vegetation density (e.g., shrubs and meadows), while high NDVI values, ranging from 0.6 to 0.8, correspond to areas with dense vegetation, such as temperate and tropical forests.

For this study, NDVI values for Naour District were extracted using the Extract by Mask tool within the Spatial Analyst toolbox in ArcGIS 10.5.

The extracted NDVI raster's were then reclassified into five classes to simplify interpretation. The reclassification process involved setting thresholds where the first break point was set at zero, and the remaining values were kept as originally calculated. The reclassified raster was then converted into a layer with an attribute table.

Supervised Classification

A cloud-free Landsat 8 Collection 2 Level-2 satellite image for the year 2022 (Path/Row: 174/38), with a spatial resolution of 30×30 meters, was downloaded from the USGS Earth Explorer website (earthexplorer.usgs.gov). The specific image used was named: LC08-L2SP-174038-20220830-20220910-02-T1.

The composite image was created by combining the seven spectral bands using the Composite Bands tool. The study area, Naour District, was extracted from the composite image using the Extract by Mask tool in ArcGIS 10.5.

Supervised classification was conducted using ArcGIS 10.5 based on user-defined training samples. These training areas were created by selecting homogeneous land use/land cover regions with the Polygon Tool on the Image Classification Toolbar. Overlapping classes were merged and labeled based on their corresponding features (e.g., forest, urban, agriculture). A signature file was generated using the Create Signature File tool in the classification manager.

Training data were segmented using the Segmentation tool under the Spatial Analyst toolbox. A total of 300 accuracy assessment points were created using the Stratified Random Sampling strategy to ensure representative distribution across all land cover types.

The Maximum Likelihood Classifier (MLC)-a commonly used algorithm in supervised classification—was applied to generate the classified thematic map. The classification process assigned each pixel to a class with the highest probability based on the training signatures.

Accuracy Assessment

Accuracy was evaluated by comparing the classified image with ground-truth data collected on 11/11/2022, while the satellite image was captured on 30/08/2022. The validation was conducted using a confusion matrix, from which the following accuracy metrics were calculated:

- **Kappa Coefficient:**

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}\left(x_{i} + Xx_{+1}\right)}{N^{2} - \sum_{i=1}^{r}\left(x_{ii} Xx_{+1}\right)}$$

Source (Sophia S. Ruwanga, J. M. Ndambuki ,2017)

Where:

- N: Total number of pixels (Total number of observation)
- r = number of rows and columns in error matrix, N = total number of observations (pixels)
- X_{ii} = observation in row i and column i,
- Xi+ = marginal total of row i, and X+i = marginal total of column i

Source: Sophia S. Ruwanga & J. M. Ndambuki (2017)

- Overall Accuracy:

$$\text{Overall Accuracy (\%)} = \left(\frac{\text{Total number of correctly classified pixels}}{\text{Total number of reference pixels}}\right) \times 100$$

- User's Accuracy:

$$\text{User's Accuracy (\%)} = \left(\frac{\text{Correctly classified pixels in a class}}{\text{Total pixels classified in that class (row total)}}\right) \times 100$$

- Producer's Accuracy:

$$\text{Producer's Accuracy (\%)} = \left(\frac{\text{Correctly classified pixels in a class}}{\text{Total actual pixels in that class (column total)}}\right) \times 100$$

- Commission Error:

Commission Error = 1 - User's Accuracy

- Omission Error:

Omission Error = 1 - Producer's Accuracy

Source: Jog & Dixit (2016)

A total of 300 accuracy points were generated using Method 2: Stratified Random Sampling to ensure spatially distributed validation across all classes. This method allowed each class to be represented proportionally based on its area, improving the reliability of the accuracy assessment.

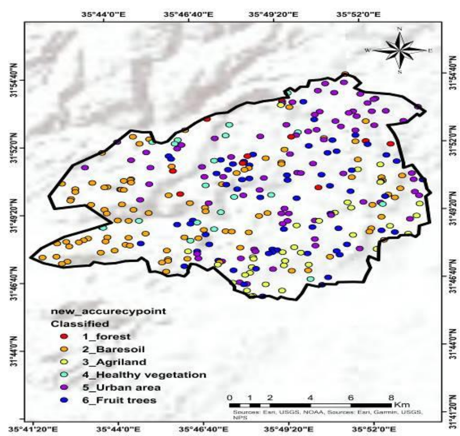

Figure 10. Training samples collected on 11/11/2022 using stratified random sampling.
Source: Researcher's work using ArcGIS 10.5.

- Directorate Data: The Directorate of Agriculture within Naour District is organized into divisions, each serving specific functions and responsibilities:
- Plant Production Division: This division is primarily concerned with various aspects related to the cultivation and management of crops. It provides a lot of specific knowledge about different crop types. Optimal cultivation practices, soil management techniques, and pest control strategies.
- Livestock Production Division: Responsible for the handling and development of livestock farming, nutritional requirements, and disease prevention protocols.
- Agricultural Extension Division: This division plays a vital role in spreading agricultural knowledge and information from the Directorate of Agriculture to farmers, it facilitates educational programs, workshops, and training programs to promote new agricultural practices and advancements.
- Division of Forestry: Focused on the preservation and management of forests and trees, this division provides detailed information about sustainable forestry practices, and wildlife conservation measures.
- Projects Division: Within this division, particular agricultural projects that improve productivity, and sustainability are developed and put into action, it is responsible for planning and executing projects related to agricultural research, and technological innovations.
- Marketing and Information Division: This division focuses on the aggregation of market-related data related to agricultural products. It analyzes market trends and provides farmers with targeted marketing strategies to optimize the promotion and sale of their produce.

Data was gathered from various divisions within the Directorate, supplemented by field visits conducted as part of my duties in Naour, and the gathered information has been geographically located.

The data gathered from the Directorate of Agriculture of Naour has been organized into Excel sheet table, including details about agricultural activities taking place on Naours land along with their corresponding geographical locations.

Joining an Excel sheets to the shape files of Naour villages using ArcGIS 10.5.

Create maps using ArcGIS 10.5 with the WGS-1984-UTM-Zone-36N coordinate system that displays the precise locations of agricultural activities within the study area.

Results and discussion

NDVI results

After extracting vegetation maps using the NDVI tool in ArcGIS 10.5 for the three date, figure (11), where the natural range of NDVI from (-1 - 1), Where positive and proximate values of 1 indicate high vegetation density, While the values approaching -1 indicate low vegetation density, Table (4):

Table (4) NDVI values

Value of NDVI	Descriptions
0.1 or less	Very low NDVI
0.2 to 0.5	Moderate NDVI
0.6 to 0.9	High NDVI

Source: (Taufik, et al., 2016)

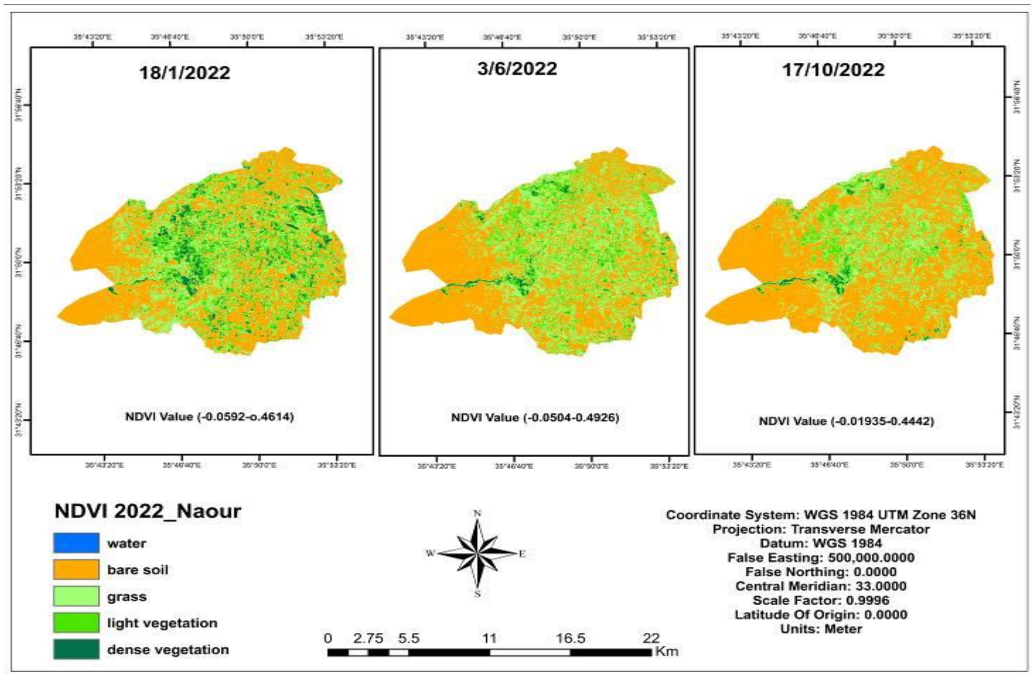

Figure 11. NDVI Values of January, June, and October Naour, 2022
Source: Researcher Work, depending on NDVI analysis using ArcGIS 10.5 based on Landsat8 satellite images

The results of the analysis showed that there were no noticeable differences between the values of vegetation density at the beginning, mid, and end of the year, table 5:

Table 2. NDVI values for the year 2022

January	June	October
-0.0592-0.4614	-0.0504-0.4926	-0.01935-0.4442

Source: Researchers Work depending on NDVI analysis from Landsat8 satellite images

After the analysis of the three satellite images based on GIS and remote sensing, the results of the vegetation areas and patterns were shown in Table (6).

Table 3. NDVI classes area (km²) and percentage (%)

CLASSES	**18/1/2022**		**3/6/2022**		**17/10/2022**	
Land cover	Area (km2)	Percentage (%)	Area (km2)	Percentage (%)	Area (km2)	Percentage (%)
Water	0.1494	0.0745	0.0486	0.0242	0.0225	0.011204
Bare soil	98.9577	49.348	109.149	54.3504	134.686	67.06627
Grass	55.0890	27.4715	62.1738	30.9592	47.0808	23.44368
Light vegetation	34.3953	17.1521	26.1783	13.0354	16.7634	8.347263
Dense vegetation	11.9403	5.9543	3.2751	1.6308	2.2725	1.131582
Sum	200.5317	100	200.8248	100	200.8252	100

Source: Researchers Work depending on NDVI analysis from Landsat8 satellite Images

Table 4. Rate of change in area (km²) and percentage (%) of the three dates of the satellite images for Naour

rate of change (18/1-3/6)		**rate of change (3/6-17/10)**	
area (km²)	Percentage (%)	area (km²)	Percentage (%)
-0.1008	-0.0503	-0.0261	-0.0130

10.1913	5.0027	25.5370	12.7159
7.0848	3.4877	-15.0930	-7.5155
-8.2170	-4.1167	-9.4149	-4.6881
-8.6652	-4.3235	-1.0026	-0.4992

Source: Researchers Work depending on NDVI analysis from Landsat satellite images using ArcGIS10.5

The water area decreased from January to June by 0.10 km² with a percentage of 0.05% , it even decreased more in October by 0.02 km² and 0.013% ,Water is a gathering of rainwater on the rooftops, especially at the site I visited in the study area where it was a company building and a printing press building where the roof was filled with watersheds for most of the time of the year (Building keeper), other water places are found in holes in rocky lands especially in the western areas, where water gathers during the winter when rain falls, some evaporate and others still have little water for the rest of the year.

-Bare Soi :I n January it reached 98.9577km² and then increased in July to 109.149 km² an increase of 10.19km² it also increase also in October and become 134.686 km² an increase of 25.537km² during the last two months. This is due to the nature of the cultivation of winter crops in October and therefore the value of bare soil reaches the highest in this month and decreases in other months due to the start of crop productivity in January and crop productivity for summer crops in July.

-Grass: It is a mixture of soil and plant with an area of 55.0890 km in January it increases to 62.17 km² in July with an increase of 7.08km². However, it decreased in October to 47.08 km² with a decrease of 7.5%. As a result of the cultivation of winter crops, which were planted in September, October, November and December for the previous year 2021 when the land is prepared for cultivation in those months, so that winter crops grow in January and mature in spring to be harvested.

-Dense vegetation: It reaches its peak in January, representing forests in the middle of the study area and leaning to the West Side. Sail Husban plays a role in the distribution of plantations, where cultivation is found throughout the year for the availability of water throughout the year.

Dense vegetation reached an area of 11.94 km² which is 5.95% to be less than in July to 3.27 km² with a percentage of 1.63%. The decrease was 8.6652% and competed more in October, where the area became 2.27 km² with a percentage of 1.1315% and a decrease of 0.499%. So, we can summarize the result in the three NDVI maps, figure (12) as follows:

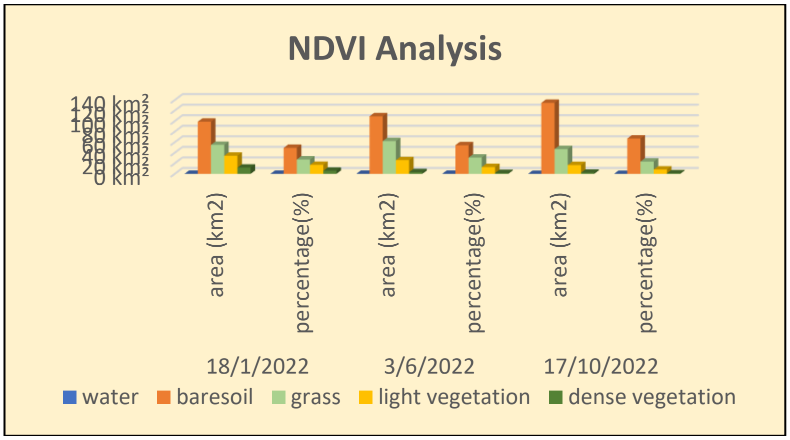

Figure 12. Area and percentage for (January, June and October) 2022 NDVI maps
Source: Researchers' Work based on NDVI analysis from Landsat satellite images using ArcGIS 10.5

Image (17/10/2022): Preparing the land for winter plantings for next year's production 2023.

Image (3/6/2022): Production of summer crops that were cultivated in April of the same year, such as okra, tomato, onion, eggplant, squash, melon, watermelon, kidney bean and sunflower, broad bean and onion are cultivated in March (rainfed) also radish and leafy vegetables are cultivated from march until the end of summer (irrigated).

Image (18/1/2022): the highest NDVI because of the winter crop production planted in the previous year (2021), and because of rainfall. Crops such as Wheat, barley, chickpeas, lentils, currants, turnips, carrots, peas, turnips, and spinach are grown from November to the middle of December (irrigated and rainfed), cauliflower and cabbage are grown from November to March.

Supervised Classification results

The study used the Landsat8 satellite image that was downloaded in the date of 30 August 2022, figure (13):

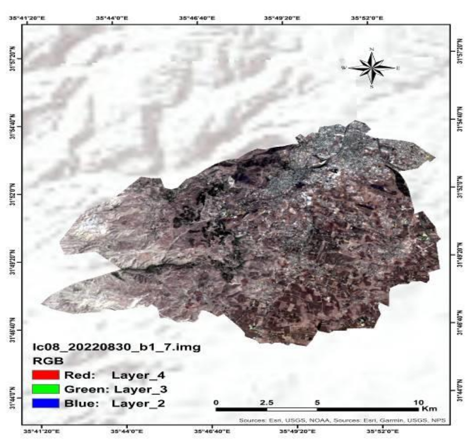

Figure 13. Landsat Satellite image 30/8/2022
Source: Researchers' Work based on the USGS Website

The results of the satellite image analysis showed patterns of land cover and land use by using a supervised classification technique, figure 14:

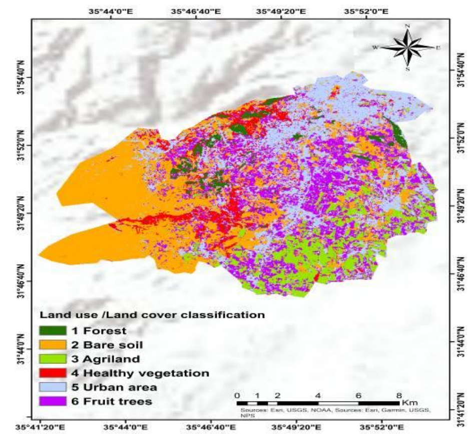

Figure 14. Land sat Satellite image 30/8/2022 supervised classification using Maximum Likelihood Classifier (MLC) type

Source: Researchers Work Areas and percentage of the six classes was found as a result of supervised classification, table (8).

	Value	**Count pixels**	**Area(km²)**	**Percent (%)**
1	Forest	6942	6.2478	3.1
2	Bare soil	71693	64.5237	32.1
3	Agri land	25188	22.6692	11.3
4	Healthy vegetation	14529	13.0761	6.5
5	Urban area	57960	52.164	26
6	Fruit trees	46826	42.1434	21

Table (5) Supervised Classification classes area (km²) and percentage (%)

Source: Researchers Work based on Supervised Classification analysis using Maximum Likelihood Classifier (MLC)

-Forests constitute 3% of the area of Naour district with a total area of 6.2478 km², a small area and is significantly decreasing because of attacks in the region on forest trees for the use of wood as firewood. Forests are concentrated in the north and north-west regions and some in the eastern side, in areas where rainfall ranges between (300 - 400) mm / year.

- Bare soil forms approximately 32% of Naour district with a total area of 64.52 km², concentrated in western areas characterized by arid warm climate, crops need irrigation in these areas, when tracking sea surface elevation, the lands are found to be within the lowlands of the sea surface (-26) m.

-Agri land are areas where irrigated cultivation such as exposed vegetables and protected cultivation, forms approximately 11.28% of Naour with an area of 22.66 km² is concentrated in the southern areas of the Naour district and the south-eastern regions. These crops are concentrated in areas above sea level from (800-900) m to a decrease in salinity in these lands, where these areas prevail xeric (Mediterranean climate) where winter is cold, wet and summer is warm and dry and receives rain between (300-350) mm due to semiarid warm climate.

-Healthy Vegetation which reflects more near infrared and green light compared to the wavelengths but it absorbs more red and blue light (Gisgeography, 2022)

This class has been classified based on the band combination (543) where the red color indicates plantation (plantation reflected in darker red). It forms approximately 6.511217% of Naour and an area of 13.0761 km², healthy vegetation located in Mediterranean climate zone, in Husban stream region in Naour where water is available, and in some areas in the north where the amount of rain reaches (400-450) mm.

-Urban areas form approximately 26% of Naour and an area of 52.164 km², it is located in the center of Naour district and in north-eastern areas. Naour is known by its natural beauty winter is moist and cool and summer are warm and dry, as it is a window into the Dead Sea and the Jordan valley. In addition to the water springs founded, all of which were a reason to attract the population to live in Naour. This urban sprawl threatens agricultural land.

-Fruit trees form approximately 21 % of Naour with an area of 42.1434 km² . This is due to the fertility of the soil and the availability of weather conditions suitable for fruit trees growth, where different types of trees planted such as stone fruits, Fig, Grapes, Guava and Olive cultivation, and it concentrated in the areas of the middle and surroundings rainfall varies in these areas (300-400) mm, farmers using wells' water to irrigate their farms. The fruit trees class is located within a Mediterranean climate and at altitudes ranging between (800-900) m above sea level.

Accuracy Assessment results

To analyze the accuracy of any classification procedure for satellite data, a quantitative analysis of the confusion matrix must be performed, table (9):

Table (6) Error Matrices Ground Truth Points

classified	Forest	Bare soil	Agri land	Healthy vegetation	Urban area	Fruit	user (total)	Users accuracy	Error of commission
Forest	6	2	0	0	0	2	10	0.6	0.4
Bare soil	0	96	0	0	0	0	96	1	0
Agri land	0	2	32	0	0	0	34	0.941176471	0.058823529
Healthy vegetation	0	3	0	17	0	0	20	0.85	0.15
Urban area	1	13	6	0	54	4	78	0.692307692	0.307692308
Fruit	0	12	8	0	0	43	63	0.682539683	0.317460317
producer(total)	7	128	46	17	54	49	301		
Producers accuracy	0.857143	0.75	0.6957	1	1	0.87755102			
Error of Omission	0.142857	0.25	0.3043	0	0	0.12244898			
overall accuracy	82.39203								
N	301								
sum of diagonal	248								
sum of (total row*total column)	21561								
Numerator	53087								
Denominator	69040								
Kappa	0.768931								

Source: Researchers' work

Where N Total number of observations

The user accuracy and the producer accuracy were obtained by dividing the correctly classified pixels of every row and column with the sum of total pixels for every row and column, the percentage of overall accuracy obtained is 82.4 %, Kappa coefficient 0.77 this result classified as into moderate accuracy for kappa coefficient.

Directorate data results

The data gathered from the Directorate of Agriculture of Naour has been organized into Excel sheet tables, including details about agricultural activities taking place on Nour's land along with their corresponding geographical locations. Upon joining the Excel sheets to the shape files within ArcGIS 10.5 the resulting outcome was an enriched dataset, the information from both sources. Dataset now offers a more comprehensive view of the agricultural activities on the land of Naour as follows:

- Plant production maps

The resulting maps showed plant production diversity in the vegetation cover within Naour district, due to several factors:

- Soil Fertility. Which includes factors such as nutrients contents (nitrogen, phosphorus, potassium) organic matter and PH plays crucial role in determining the distribution of plant species , In Naour , variation in soil quality – driven by natural condition and human activities such as agriculture and urban expansion _ directly impact the composition and diversity of local vegetation . Areas with higher organic matter and balanced nutrients levels tend to to support greater variety of plants, while degraded soils often exhibit reduced biodiversity.

-The rainfall rate exceeds 350 mm, the average rainfall for the last ten years was 465.1 mm, with the maximum rainfall in 2019/2020 reaching 722 mm and the lowest in 2016/2017 reaching 298 mm. (Naour Directorate records, 2021).

-Rainy season takes place in October and extends until April, with occasional rainfall occurring in May. During this period, the most substantial precipitation is observed in December, January, and February.

-Presence of many springs (17), valleys, and artesian (10) wells, in Naour.

- Naour diverse topography influences the types of crops that can be grown in different parts of the district, from the highlands and plateaus to plains.

Wheat and barley: These are traditional cereal crops grown in Husban, ALsamek and Um albsateen.

Fruits: Apples, pears, cherries, and peaches are cultivated in most of Naour villages with suitable conditions.

Olives: Olives are grown in various parts of the highlands and are an essential part of Naour's agriculture.

Vegetables: A wide range of vegetables, including potatoes, onions, and carrots, are grown in the highlands, figures (15):

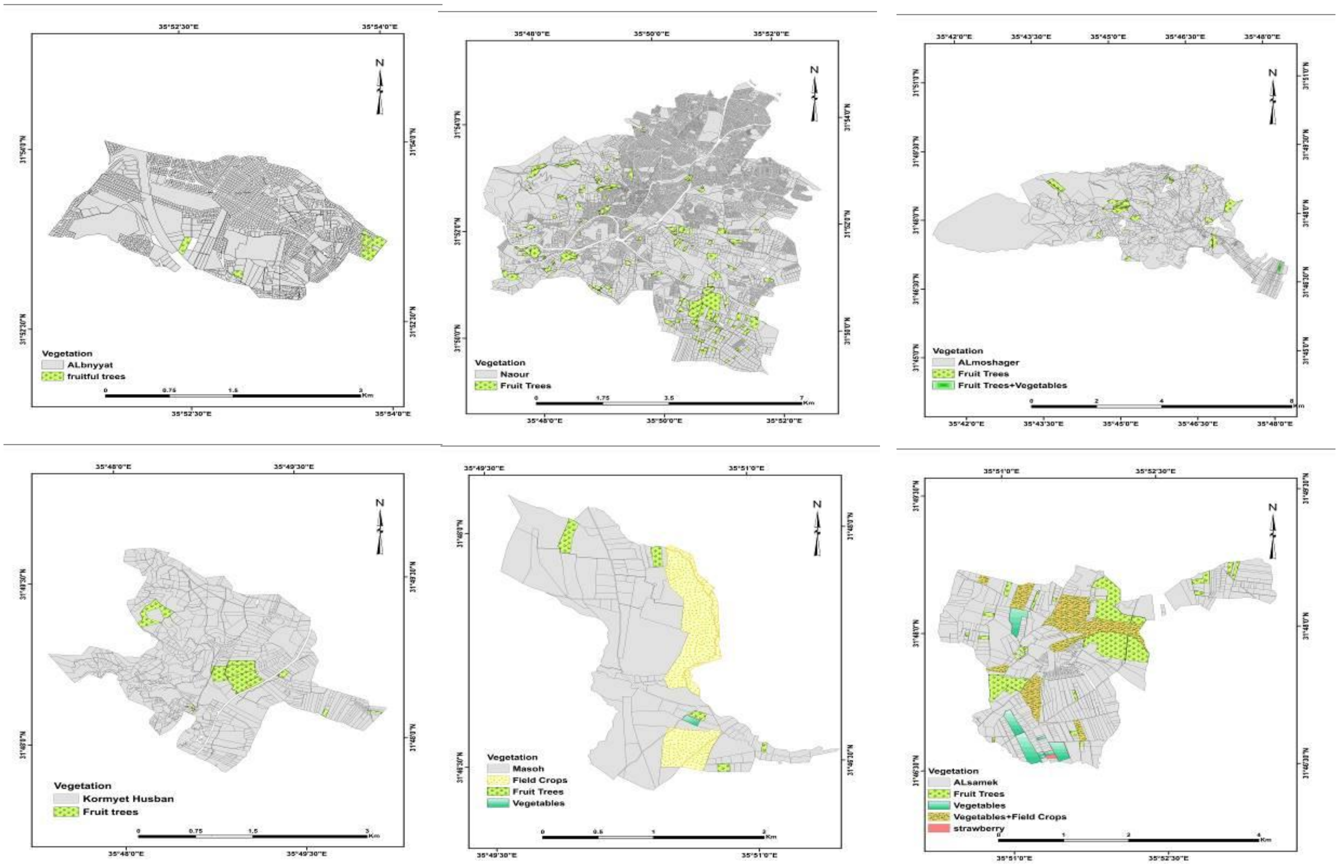

Figure 15. Naour District vegetation

Source: Researchers work by using ArcGIS 10.5 based on Naour directorate data and field work

-Livestock Production division maps.

Livestock plays a significant role in Jordan's agricultural sector and economy. Livestock farming contributes to food security and income generation for many farmers, the livestock sector in Naour includes various types of animals:

- Cattle: Farmers in Naour raise cattle for their dairy products and beef, providing a vital source of protein. There are five cattle farms in Naour with a capacity of (275) heads.

- Sheep and Goats: Sheep and goats are essential for both meat and milk production. They are well-suited to the arid and semi-arid conditions of Naour and are a valuable source of income for many rural communities.

- Poultry: Poultry farming, including chickens, is widespread in Naour. Poultry products like eggs and meat are in high demand and are an important part of the local diet.

- Horses: there are six horse farms with a capacity of (387) heads, in Naour farmer raises horses for various purposes :Cultural and Traditional Practices, Recreational Activities, Tourism and Entertainment, and Racing and Competitions. Farms in Naour and their locations, figure (16):

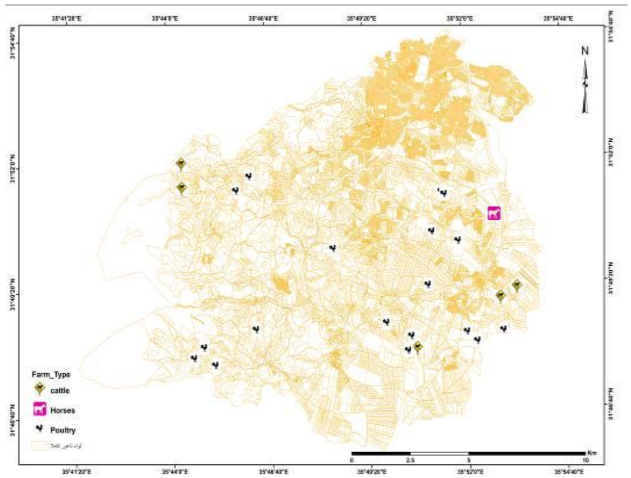

Figure 16. Naour Livestock

Source: Researchers work by using ArcGIS 10.5 based on Naour directorate data and field work

-Projects Division maps

Land reclamation projects in Naour have been undertaken to avoid desertification, soil erosion, and reclaim unproductive land for agricultural use. These projects aim to improve the quality and fertility of the soil, increase agricultural productivity, and promote sustainable land management practices.

Construction works, various means of soil preservation, such as stone walls and, Water channels which are used as physical barriers to control soil movement and retain soil in place.

Water harvesting works, specifically wells and water collection tanks, are essential components of water management strategies used to capture and store rainwater and runoff in areas with limited water resources or irregular rainfall patterns. These techniques aim to increase water availability for various purposes, including agricultural irrigation, and livestock watering.

Planting trees, is an effective and natural way to prevent soil erosion and promote soil conservation. Trees play a vital role in stabilizing soil and reducing erosion through various mechanisms: Root system: The root system acts as a natural anchor, increasing soil cohesion and reducing erosion. Canopy cover: The canopy of trees provides shade and intercepts rainfall. This slows down the impact of raindrops on the soil surface, preventing soil erosion. Windbreaks: Trees planted as windbreaks help shield the soil from strong winds.

Three projects were accomplished in Naour named: (Husban project, Reclamation project and Al kafreen project), figure (17):

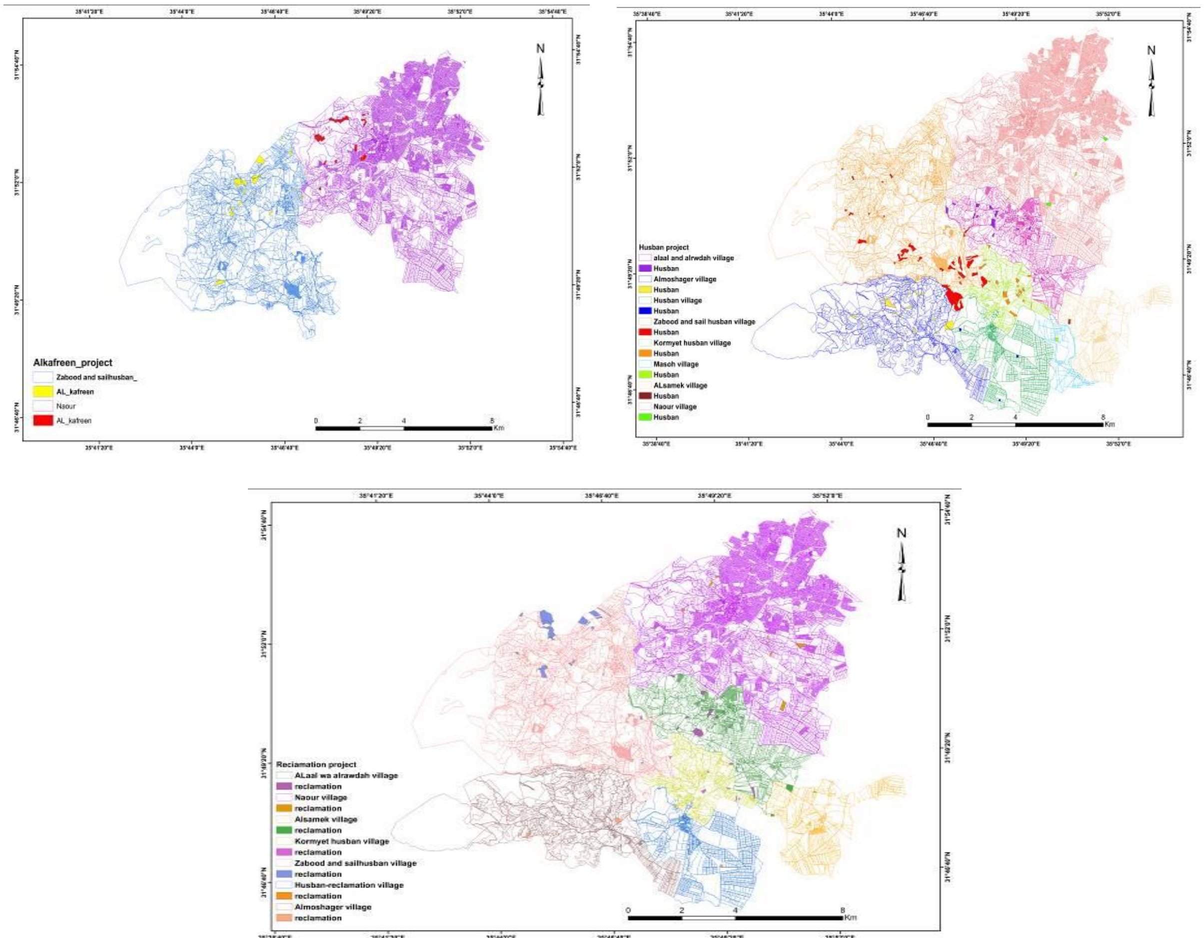

Figure 17. Alkafreen project, Husban project, Reclamation project

Source: Researchers work by using ArcGIS 10.5 based on Naour directorate data and field work

-Forest division maps

Forest in Naour _as in Jordan -faces some challenges, it has limited forest cover due to its arid climate and water scarcity, in addition to urban expansion factor that contributes to the depletion of the forest in the region, in Naour district, there is a total of 36000 dunums of forest land. Out of this, 8000 dunums are actively utilized for forest trees, with 7293 dunums forming organized forests and 703 dunums consisting of scattered forest trees, primarily planted with juniper, Cinchona, Nerium. (Directorate records, 2021) The district comprises a total of 23 forests, figure (18):

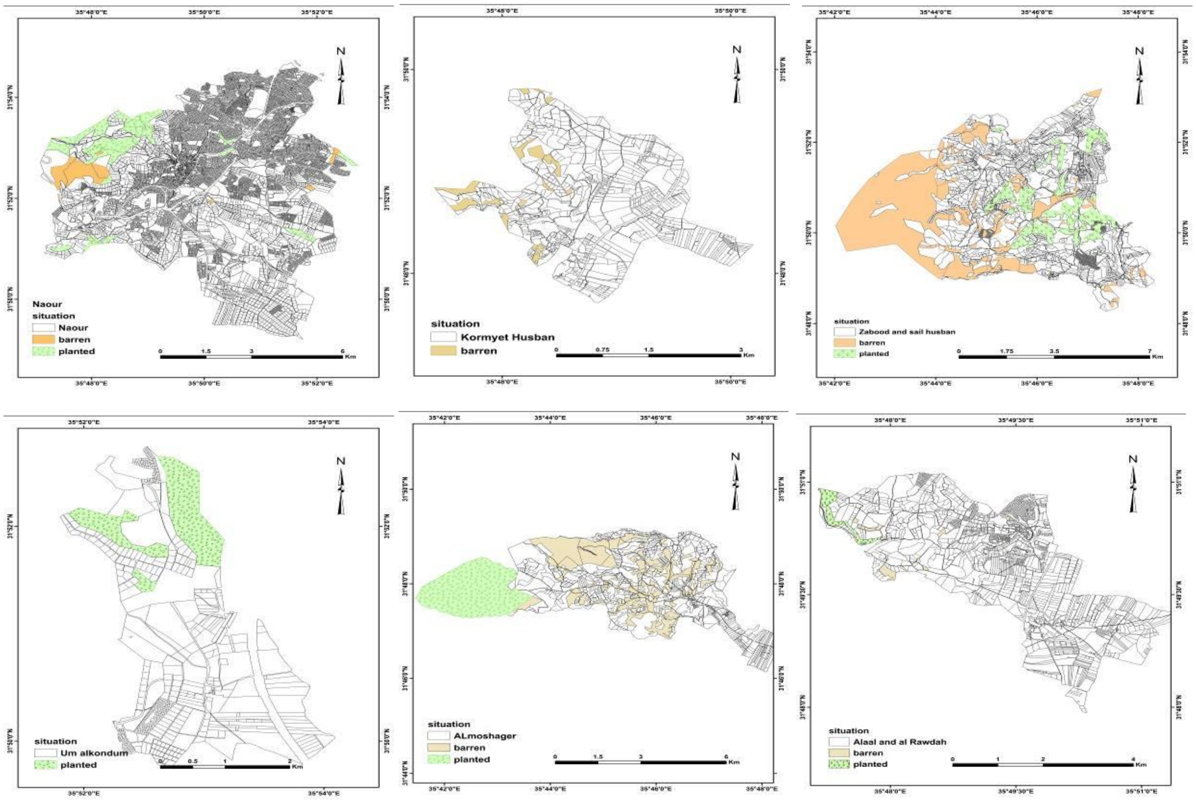

Figure 18. Naour District forest

Source: Researchers work by using ArcGIS 10.5 based on Naour directorate data and field work

-Agricultural Facilities Maps

There are different Agricultural establishments in Naour such as (nurseries, exhibitions, flower shops, companies and stores of seeds, fertilizers and pesticides, olive presses), figure (19):

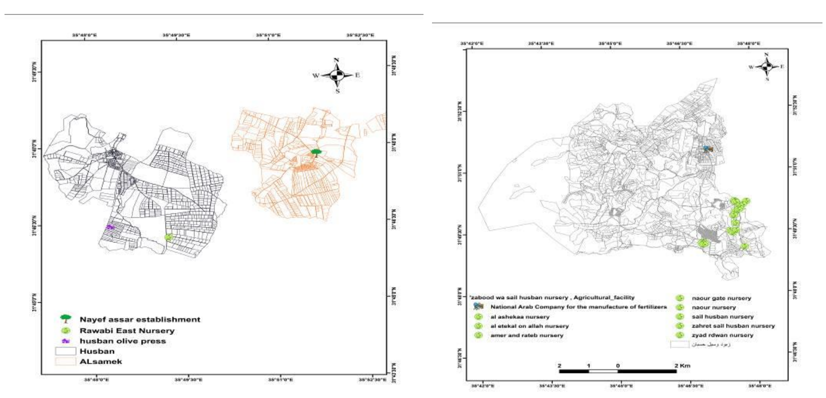

Figure 19. Agricultural Facilities in Naour District

Source: Researchers work by using ArcGIS 10.5 based on Naour directorate data and field wok

Conclusion

The creation of agricultural activity maps provided valuable insights into the spatial distribution and extent of various agricultural activities across Naour District. These visualizations enable more effective planning and resource allocation. With access to precise spatial data, decision-makers can identify suitable areas for cultivating specific crops, optimize water usage, and support the development of agricultural infrastructure.

Crop management practices have also been enhanced through the availability of detailed maps that reflect soil characteristics, topographic features, and microclimatic zones. This allows farmers to make informed decisions regarding irrigation scheduling, fertilizer application, and pest control strategies, thereby improving crop productivity and minimizing environmental impacts.

Findings derived from the Normalized Difference Vegetation Index (NDVI) indicate that land cover across the study area includes water bodies, bare soil, grasslands, light vegetation, and dense vegetation. The NDVI values for the selected three time points in 2022 ranged from –0.01935 to 0.4926, reflecting seasonal variations in vegetation density.

Results from supervised classification further identified six major land cover categories: forest (3.11%), bare soil (32.12%), agricultural land (11.28%), healthy vegetation (6.51%), urban areas (25.97%), and fruit tree plantations (20.98%). These classifications provide a strong foundation for monitoring land use changes and evaluating agricultural sustainability in the region.

Recommendations

It is recommended that the agricultural database established for Naour District continue to be expanded until full spatial coverage is achieved. This will ensure the long-term utility of the system and support more comprehensive planning.

Given the dynamic nature of the agricultural sector, it is critical that Agricultural information in the Naour Directorate must be updated regularly. Frequent data updates will enable rapid and accurate decision-making, allowing policymakers to develop adaptive strategies for sustainable agricultural development.

The computerized database should be actively utilized in several key areas: Generating spatial reports on agricultural activities, supporting the formulation and implementation of evidence-based policies, and strengthening food security efforts through access to real-time, reliable data.

To achieve these objectives, the Ministry of Agriculture is advised to provide the following support: specialized software for geospatial analysis (e.g., ArcGIS), modern computing equipment including printers and scanners, GPS devices (at least one per division), vehicles for conducting field surveys, and ongoing training programs to enhance staff competencies in GIS and remote sensing technologies.

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